

TABLE OF CONTENTS

1.	INTRODUCTION	1
2.	MONITORING.....	2
2.1	Injected Fluids.....	2
2.2	Injection Pressure and Flow Volumes	3
2.3	Mechanical Integrity	4
2.4	Part 1 Mechanical Integrity Requirement	4
	2.4.1 Part 2 Mechanical Integrity Requirement	4
2.5	Groundwater Monitoring	5
	2.5.1 Monitoring Locations.....	5
	2.5.2 Monitoring Parameters.....	5
	2.5.3 Analytical Methods	5
	2.5.4 Groundwater Sampling Protocols	6
2.6	Hydraulic Control Monitoring	6
	2.6.1 Fluid Levels	6
	2.6.2 Specific Conductance Monitoring	6
	2.6.3 Injection vs. Extraction Volumes.....	7

TABLES

P-1	POC, Observation, and Hydraulic Control Well Information
P-2	Proposed Ambient Groundwater Quality Monitoring Parameters

FIGURES

P-1	Proposed Locations of Hydraulic Control, Point of Compliance, and Observation Wells
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1. INTRODUCTION

This Attachment was prepared in support of Excelsior Mining Arizona, Inc.'s (Excelsior's) Underground Injection Control (UIC) Permit application to the United States Environmental Protection Agency (USEPA). Excelsior is applying for an area Class III UIC permit to install a wellfield for in-situ recovery (ISR) of copper at the Gunnison Copper Project (Project), located in Cochise County, Arizona.

This attachment describes the monitoring program that Excelsior proposes to conduct in accordance with the monitoring requirements of Chapter 40 of the Code of Federal Regulations (CFR) §146.33(b).

Elements of this proposed monitoring program include:

- Monitoring of injected fluids
- Operational monitoring—injection pressure and flow
- Mechanical integrity monitoring
- Groundwater quality monitoring
- Hydraulic control monitoring

2. MONITORING

2.1 Injected Fluids

40 CFR §146.33(b)(1) requires monitoring of the nature of injected fluids with sufficient frequency to yield representative data on its characteristics. In addition, whenever the injection fluid is modified, monitoring is required.

The term “lixiviant” or “barren leach solution” is used in this application for the injected fluid. The anticipated composition of lixiviant is provided in Attachment H-2. The estimated chemical composition of mature barren leach solution is based on Johnson Camp Mine (JCM) raffinate, except fluoride, iron, and copper¹. It should be noted that the chemical composition of the barren leach solution will evolve over the life of the mine from acidified groundwater to the mature composition as reported in Attachment H-2. The composition of the mature leach solution is reasonably consistent with time because the dissolution and precipitation reactions that control the composition approach equilibrium and no longer cause substantial changes in the leach solution chemical load.

Lixiviant solutions will be monitored on a *monthly* basis during leaching operations for the following analytes:

- Dissolved Metals: aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, zinc.
- General Chemistry, alkalinity (milligrams per kilogram as CaCO₃), pH (standard units.), total dissolved solids
- Anions: chloride, fluoride, nitrate (as N), sulfate
- Organics: Total Petroleum Hydrocarbons

In addition, on an *annual* basis during leaching operations, lixiviant will be analyzed for the following: Ra-226 + Ra-228 (picocuries per liter), and uranium (milligrams per liter).

¹ Projected fluoride concentrations in lixiviant were increased to adjust for a low bias caused by matrix interference in the JCM lixiviant. Projected iron concentrations in Gunnison Copper Project lixiviant were increased based on metallurgical testing of the Project ore. Copper concentrations in Project ore are based on an anticipated operational PLS grade of 1.5 grams per liter and standard SX/EW efficiency of 90 percent.

2.2 Injection Pressure and Flow Volumes

40 CFR §146.33(b)(2) requires “monitoring of injection pressure and either flow rate or volume semi-monthly, or metering and daily recording of injected and produced fluid volumes as appropriate.”

Injection pressure will be monitored in each injection well with a pressure gauge to ensure that pressures don’t exceed allowable limits. Injection pressures will be metered and recorded daily in the header houses. The pressure will not exceed 0.75 pounds per square inch per foot (psi/ft), based on results of fracture gradient testing conducted in 2015. The fracture gradient testing report is provided in Attachment I-2.

Injection and recovery wells for each mining block will be plumbed to injection and extraction headers in a centralized “header house” building. Each header house will be connected to up to 60 wells. Mechanical equipment in the header house consists of flow control valves on the injection and recovery wells. Recovery wells will be equipped with submersible pumps with starters and controls in the header house. Sampling ports will be accessible in the header houses.

Instrumentation for the injection and recovery wells will be similar (see Figure K-6). Each well will be equipped with a magnetic flow meter.

The mechanical equipment and instrumentation will be controlled and monitored by a computerized plant control system (PCS) located in the wellfield control room in the EW building. Communications between the PCS and the wellfield is maintained using a fiber-optic/Ethernet network or other such appropriate communications network. Each header house will consist of a climate-controlled room with motor starters and monitoring and control equipment connected to the PCS. Communication between the PCS and the main control enclosure will be by fiber-optic cable. Pressure gauges will be read and recorded manually and flows will be controlled by manual adjustment of the control valves.

The operator in the control room will use the PCS to monitor flow rates at each well to ensure that flow balance is maintained. Conditions out of the operating range or needing correction will be reported to the wellfield operators who will manually adjust the controls. Sensitive electronic equipment will be kept cool and dry in a separate, air conditioned compartment and a human-machine interface (HMI) in the “wet” side of the header house will allow the wellfield operators to monitor operational parameters, such as flow rates and power consumption, and adjust the flow control valves manually.

The PCS will also be equipped with data loggers to record information from the instruments at each well to enable the operator to examine trends, calculate local and cumulative flows, set alarm conditions, and maintain production records. The PCS will provide trending, historical and alarm data for flow, power draw, and any other required instrumentation. Injection pressure will be recorded manually and entered electronically to the data loggers to ensure that injection pressure is stable and doesn’t exceed the stipulated limits. Alarms will be triggered when flow rates or fluctuations are out of limits set by the operator. Alarms will also be generated when

there is a communications fault, equipment or instrument failure or a process that is out of control limits.

2.3 Mechanical Integrity

According to §146.08, an injection well has mechanical integrity if:

- (1) there is no significant leak in the casing, tubing or packer; and
- (2) there is no significant fluid movement into an underground source of drinking water through vertical channels adjacent to the injection well bore.

Observation wells, which are described in Attachment M, will only be used for measuring of water levels to demonstrate hydraulic control. Although they will be located inside the AOR, it is not necessary to conduct mechanical integrity testing on these wells, as they will not be used for injection or recovery of process solutions.

2.4 Part 1 Mechanical Integrity Requirement

In order to meet the Part 1 requirement, Excelsior proposes to conduct a Standard Annulus Pressure Test (SAPT) for injection/recovery wells having construction as shown on Figures M-1 or M-2 in Attachment M. The test will be conducted prior to operation of the well. A packer will be installed near the bottom of the cased interval, and the casing will be completely filled with water. A hydraulic pressure equal to or above the maximum allowable wellhead injection will be applied. The test shall be for a minimum of thirty (30) minutes. The well will be considered to have passed if there is less than a five (5) percent change in pressure during the 30 minute period.

If a packer completion is used (as shown on Figure M-3 in Attachment M), mechanical integrity testing of the tubing-casing annulus pressure will be conducted according to UIC requirements.

Part 1 mechanical integrity testing will be conducted prior to a Class III injection/recovery well being put into service and at such time there is reason to suspect a well failure. The testing results will be included in the UIC quarterly report that is submitted to the EPA under the requirements of the permit.

2.4.1 Part 2 Mechanical Integrity Requirement

As presented in Attachment S, the alluvium above the injection zone is not a USDW. The alluvium is unsaturated through most of the Area of Review. Where saturated alluvium exists it is thin and limited in areal extent. Therefore, there can be no significant fluid movement into an

USDW through vertical channels adjacent to the injection well bore. Part 2 mechanical integrity testing is not necessary and will not be conducted.

2.5 Groundwater Monitoring

2.5.1 Monitoring Locations

Water Quality monitoring will be conducted at Point of Compliance (POC) wells established for the wellfield² in the Aquifer Protection Permit (APP) by the Arizona Department of Environmental Quality (ADEQ). The wellfield POC wells will be installed as mining progresses. A schedule for POC well installation is included in a proposed compliance schedule in the Aquifer Protection Permit application. The proposed locations of the five POC wells are provided on Figure P-1. Location coordinates are on Table P-1. The well locations are preliminary, pending approval of ADEQ and EPA. These wells will be located just outside the AOR and they will not be used for injection/recovery. They are not considered Class III wells.

2.5.2 Monitoring Parameters

Prior to operation of the wellfield, POC monitor wells will be installed and monitored for ambient groundwater quality parameters. The proposed parameters are provided on Table P-2. After 8 monthly rounds of ambient groundwater quality monitoring, the analytical results will be analyzed using statistical methods in ADEQ's standard methodology (ADEQ, 2004b) and alert levels, aquifer quality levels, and compliance groundwater monitoring parameters will be proposed. AQLs will only be calculated for those constituents having Aquifer Water Quality Standards (AWQSS) according to the methodology. Alert levels for other constituents may be proposed if they are considered an indicator parameter for excursions, according to the methodology.

It is proposed that ambient and compliance and groundwater monitoring conducted according to the pending Aquifer Protection Permit be provided to USEPA to meet groundwater monitoring requirements for the UIC permit.

2.5.3 Analytical Methods

EPA-approved methods will be used for analyses. Detection limits will be sufficient to determine compliance with the regulatory limits of the permit. If regulatory limits have not been established, detection limits will be below applicable maximum contaminant levels and/or

² Additional POC wells for other APP facilities will be installed and monitored under the APP. However, these wells will not be constructed or located so as to adequately monitor the wellfield, so they are not pertinent to this application.

AWQSS. Analyses will be performed by a laboratory licensed by the Arizona Department of Health Services, Office of Laboratory Licensure and Certification. All analytical work will meet quality control standards specified in the approved methods.

2.5.4 Groundwater Sampling Protocols

A Sampling and Analyses Plan (SAP) will be prepared prior to implementation of the compliance groundwater monitoring program to ensure consistency and sample integrity. It will include schedules, analytical methods and detection limits, documentation forms and requirements, quality assurance and quality control measures, chain-of-custody requirements, and sample collection protocols.

2.6 Hydraulic Control Monitoring

2.6.1 Fluid Levels

Hydraulic control will be monitored by measuring fluid levels in observation well pairs installed in bedrock. One well of the pair will be located within a few (10-20) feet of a hydraulic control well and the second will be located more distant from the ISR wellfield. Hydraulic control will be assessed by measuring and comparing water elevations in the paired wells. Higher water elevations in the outer (distant) observation well than in the inner well (closer to the wellfield) will be considered a satisfactory demonstration of hydraulic control.

Fluid level monitoring to evaluate hydraulic control will be accomplished using pressure transducers (or other appropriate devices) placed in the observation wells. Six daily measurements (spaced four hours apart) will be used to calculate daily average water levels.

2.6.2 Specific Conductance Monitoring

Specific conductance in the observation wells will be monitored to augment hydraulic control monitoring. An increase in specific conductance in the outer observation well may indicate the potential for an excursion from the wellfield. Grab samples of the fluid from the observation wells will be measured in the field with a calibrated instrument. Trends in the specific conductance will be evaluated and pumping from the hydraulic control wells may be adjusted based on the results.

Specific conductance monitoring to evaluate hydraulic control will be conducted monthly.

2.6.3 Injection vs. Extraction Volumes

Net solution extraction in the wellfield is a third component of hydraulic control for the wellfield. This net pumping rate will vary, depending on the location(s) of pumping at any given time. Modeling in support of the AOR determination (Attachment A) shows a net drawdown within the AOR as a result of this net pumping. A net pumping volume or rate is not proposed for this permit. As discussed in Section 2.2 of this attachment, total injection and production volumes will be monitored and recorded daily.

The proposed permit condition is that the 30-day rolling average of total volume of injected fluids will not exceed the 30-day rolling average of total volume of recovered fluids (production plus hydraulic control pumping). If the 30-day rolling average of the injection volume exceeds the 30-day moving average of production plus hydraulic control pumping, the contingency plan requirements will be implemented.

TABLE P-1
POC, Observation, and Hydraulic Control Well Information

Well Name	Latitude			Longitude			Associated Facility
	Degrees	Minutes	Seconds	Degrees	Minutes	Seconds	
Point of Compliance Wells							
1	32	4	46.4	110	2	25.5	ISR Wellfield
2	32	4	48.6	110	2	3.5	ISR Wellfield
3	32	5	1.0	110	2	5.4	ISR Wellfield
4	32	5	18.4	110	2	19.9	ISR Wellfield
5	32	5	25.3	110	2	39.0	ISR Wellfield
Observation Wells							
OW-01-I	32	4	47.4	110	2	41.1	
OW-01-O	32	4	46.5	110	2	41.4	
OW-04-I	32	4	47.3	110	2	31.0	
OW-04-O	32	4	46.4	110	2	30.0	
OW-07-I	32	4	47.8	110	2	21.3	
OW-07-O	32	4	46.3	110	2	20.4	
OW-10-I	32	4	52.8	110	2	18.8	
OW-10-O	32	4	52.8	110	2	16.7	
OW-13-I	32	4	58.6	110	2	20.0	
OW-13-O	32	4	58.3	110	2	17.9	
OW-16-I	32	5	3.5	110	2	23.7	
OW-16-O	32	5	3.5	110	2	21.5	
OW-19-I	32	5	6.6	110	2	28.1	
OW-19-O	32	5	7.9	110	2	26.5	
OW-22-I	32	5	9.7	110	2	33.9	
OW-22-O	32	5	10.8	110	2	32.3	
OW-25-I	32	5	18.6	110	2	37.4	
OW-25-O	32	5	19.5	110	2	35.6	
OW-28-I	32	5	21.6	110	2	44.1	
OW-28-O	32	5	23.5	110	2	43.0	
OW-30-I	32	5	2.6	110	2	44.5	
OW-30-O	32	5	0.8	110	2	44.8	
Hydraulic Control wells							
HC-01	32	4	47.4	110	2	37.8	
HC-02	32	4	47.4	110	2	41.3	
HC-03	32	4	47.5	110	2	34.3	
HC-04	32	4	47.4	110	2	30.8	
HC-05	32	4	47.6	110	2	27.4	
HC-06	32	4	48.0	110	2	23.7	
HC-07	32	4	48.0	110	2	21.4	
HC-08	32	4	48.8	110	2	19.1	
HC-09	32	4	50.8	110	2	17.9	
HC-10	32	4	52.8	110	2	19.1	
HC-11	32	4	54.7	110	2	19.1	
HC-12	32	4	56.7	110	2	19.1	
HC-13	32	4	58.7	110	2	20.2	
HC-14	32	5	0.7	110	2	21.4	
HC-15	32	5	1.7	110	2	23.7	

TABLE P-1
POC, Observation, and Hydraulic Control Well Information

Well Name	Latitude			Longitude			Associated Facility
	Degrees	Minutes	Seconds	Degrees	Minutes	Seconds	
HC-16	32	5	3.4	110	2	23.8	
HC-17	32	5	4.1	110	2	25.2	
HC-18	32	5	4.9	110	2	26.9	
HC-19	32	5	6.6	110	2	28.3	
HC-20	32	5	7.6	110	2	30.7	
HC-21	32	5	9.6	110	2	34.1	
HC-22	32	5	9.6	110	2	31.8	
HC-23	32	5	14.5	110	2	36.5	
HC-24	32	5	16.5	110	2	36.5	
HC-25	32	5	18.5	110	2	37.6	
HC-26	32	5	19.5	110	2	41.2	
HC-27	32	5	20.1	110	2	38.8	
HC-28	32	5	21.6	110	2	43.8	
HC-29	32	5	2.8	110	2	52.9	
HC-30	32	5	2.7	110	2	44.4	

Notes:

ISR = in-situ recovery

PLS = pregnant leach solution

TABLE P-2
Proposed Ambient Groundwater Quality Monitoring Parameters

GENERAL CHEMISTRY		
Parameter	AQL	AL
Ph (field)	None	Monitor
Specific conductance (field)	None	Monitor
Temperature (field)	None	Monitor
Bicarbonate	None	Monitor
Calcium	None	Monitor
Carbonate	None	Monitor
Chloride	None	Monitor
Fluoride	TBD	TBD
Magnesium	None	Monitor
Nitrate+ Nitrite as N	TBD	TBD
Potassium	None	Monitor
Sodium	None	Monitor
Sulfate	None	Monitor
TDS	None	Monitor

METALS		
Parameter	AQL	AL
Aluminum	None	Monitor
Antimony	TBD	TBD
Arsenic	TBD	TBD
Barium	TBD	TBD
Beryllium	TBD	TBD
Cadmium	TBD	TBD
Chromium (total)	TBD	TBD
Cobalt	None	Monitor
Copper	None	Monitor
Iron	None	Monitor
Lead	TBD	TBD
Manganese	None	Monitor
Mercury	TBD	TBD
Nickel	TBD	TBD
Selenium	TBD	TBD
Thallium	TBD	TBD
Zinc	None	Monitor

ORGANICS		
Parameter	AQL	AL
Benzene	TBD	TBD
Toluene	TBD	TBD
Ethylbenzene	TBD	TBD
Xylenes	TBD	TBD
Napthalene	None	TBD
Octane	None	TBD
TPH--Diesel	None	TBD

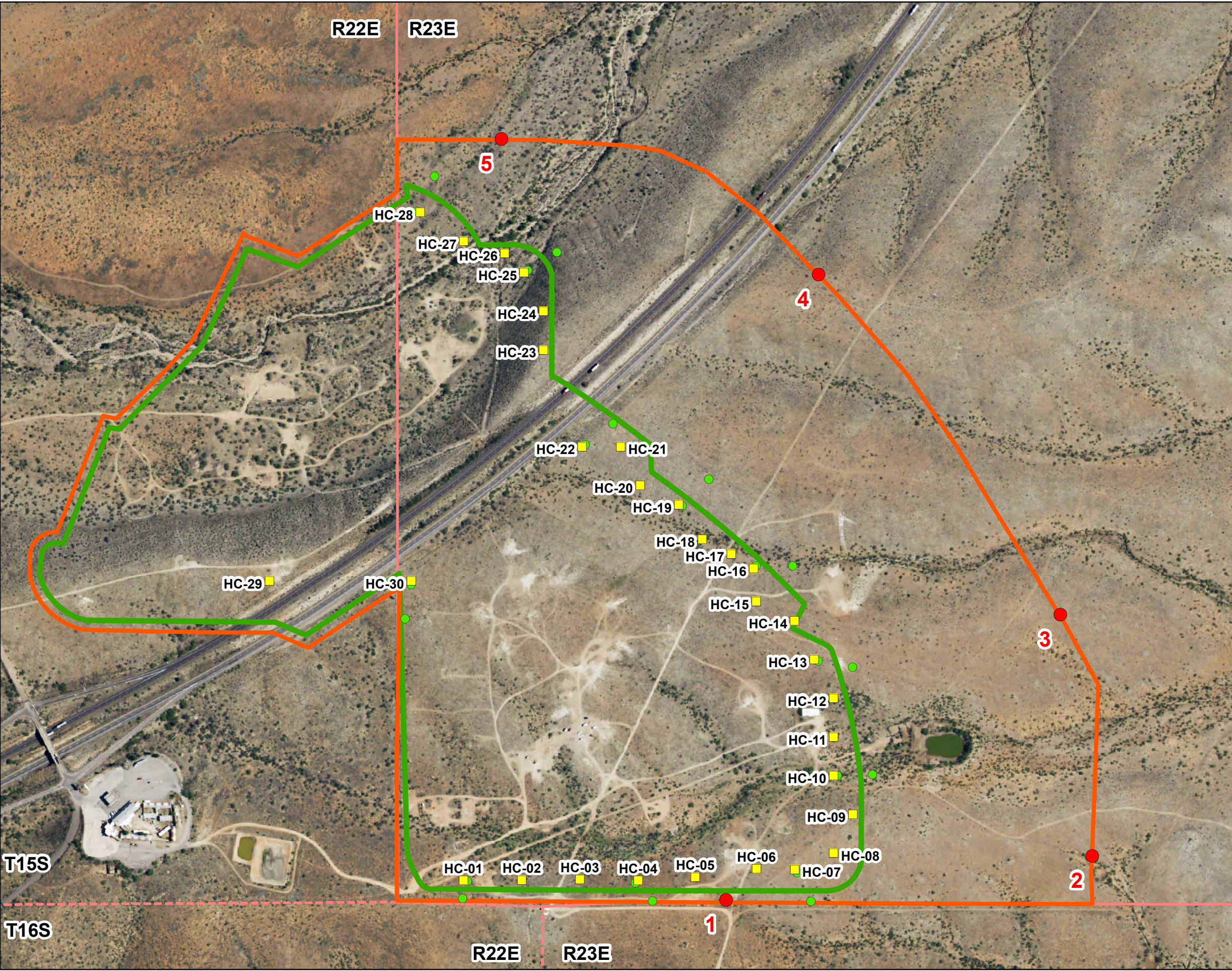
RADIOCHEMICALS		
Parameter	AQL	AL
Adjusted Gross Alpha	TBD	TBD
Uranium Isotopes activity	Monitor	Monitor
Radium 226 + Radium 228	TBD	TBD
Radon	Monitor	Monitor
Uranium (total)	Monitor	Monitor

Notes:

AL = Alert Level

AQL = Aquifer Quality Limit

TBD = To Be Determined



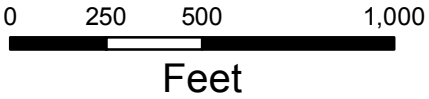
Legend

- Point of Compliance Well
- Hydraulic Control Well
- Observation Well
- Area of Review
- ISR Wellfield

Observation Wells will have same number as associated hydraulic control well.

Example: At HC-1, observation wells will be named:

- OW-1-I (inner)
- OW-1-O (outer)



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**CLEAR
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FIGURE P-1
Area of Review, Point of
Compliance, Hydraulic Control,
and Observation Well Locations